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WATER SUPPLY AND WATER QUALITY CONTROL STUDY BIG HILL RESERVOIR BIG HILL CREEK, KANSAS. STUDY OF NEEDS AND VALUE OF STORAGE FOR MUNICIPAL AND INDUSTRIAL WATER SUPPLY AND WATER QUALITY CONTROL

Public Health Service
Dallas, Texas

August 1965

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY BIG HILL RESERVOIR BIG HILL CREEK, KANSAS

Study of Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

AUGUST 1963

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WATER SUPPLY

AND

WATER QUALITY CONTROL STUDY

BIG HILL RESERVOIR

BIG HILL CREEK, KANSAS

Abstract

A survey has been made which discloses a future need for municipal and industrial water supplies from the proposed Big Hill Reservoir project. There is no foreseeable need for storage for the control of stream quality. These conclusions are based on results of economic and demographic studies.

Prepared for

DEPARTMENT OF THE ARMY

U.S. Army Engineer District

Tulsa, Oklahoma

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

AUGUST 1965

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I. INTRODUCTION

Authority

In a letter dated June 10, 1964, the U.S. Army Engineer District, Tulsa, Oklahoma, requested that the Public Health Service review the water supply needs below Big Hill Reservoir which were presented in earlier Public Health Service reports. It was also requested that the 50-year projections presented in a report dated July 1960 be extended to include a 100-year period.

In addition, the Public Health Service was requested to make the necessary studies to determine the need for providing releases from Big Hill Reservoir for downstream water quality control.

This study has been done in accordance with (1) a Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare, dated November 4, 1958 relative to Title III of the Water Supply Act of 1958, as amended (43 U.S.C. 390b) and (2) the Federal Water Pollution Control Act (33 U.S.C. 466 et seq.).

Purpose and Scope

The purpose of this study was to determine the need for and value of storage for municipal, industrial, and water quality control purposes, to the year 2070, in that part of the Verdigris River basin which might reasonably be served by the Big Hill project. In developing these needs, studies were made of Montgomery, Neosho, and Labette Counties, Kansas.

Acknowledgments

Appreciation is expressed to the following organizations who gave council and technical advice during the preparation of this report:

U.S. Army Engineer District, Tulsa, Oklahoma
Kansas Water Resources Board, Topeka, Kansas
Kansas State Department of Health, Topeka, Kansas

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. Big Hill Reservoir will be constructed in two stages. The first stage will have a yield of 4.5 million gallons daily (mgd) while the total project will yield 8.5 mgd. It will be located in southeast Kansas on Big Hill Creek, a tributary of the Verdigris River. The Big Hill Creek watershed is contained within Montgomery, Neosho, and Labette Counties, Kansas.

2. The major urban center affected by the project is Coffeyville, Kansas, which is located on the Verdigris River approximately 1 mile below the confluence of the Verdigris River and Big Hill Creek. Other municipalities in the study area include Independence, Parsons, Cherryvale, and Mound Valley, Kansas.

3. The population of the study area has shown a slight decline over recent years due to increased mechanization of farm operations, the transfer of railroad supporting facilities, and the curtailment of military production. The 1960 urban population was 45,797.

4. The quality of water in Big Hill Creek is suitable for municipal and industrial use and is expected to improve as brines now finding their way into the creek will be reinjected to the oil-bearing strata with the continuance of the very active State pollution control program.

5. The municipalities included in this study had a 1963 water use of 5.82 mgd. In addition, the Cooperative Refinery Company at Coffeyville had a water use of 2.2 mgd.

Conclusions

1. Industrial expansion, urbanization, and the assurance of adequate water supply are expected to reverse the population trend. The project study area urban population is expected to increase to 80,600 in 2020 and to 134,300 in 2070.

2. There is an immediate need for storage to improve the dependability of water supplies in the study

area. Projected municipal and industrial water demands are 13.5 mgd in 2020, and 22.0 mgd in 2070.

3. Minimum flows must be maintained in the Verdigris River to assimilate adequately treated wastes from Independence and Coffeyville, Kansas, in order to assure stream quality for possible reuse. Based on minimum flows from the operation of the existing Fall River, Toronto, and Elk City Reservoirs, there will be no additional need for storage for quality control in Big Hill Reservoir.

4. The undiscounted value of benefits attributed to storage in the first stage of Big Hill Reservoir for municipal and industrial water supply purposes is estimated to be $98,100 annually. This estimate is based on the cost of the most likely alternate source of water in absence of the project.

5. With no foreseeable need for storage to control water quality, there is no benefit attributable to storage in Big Hill Reservoir for this purpose.

III. PROJECT DESCRIPTION

Location

The proposed Big Hill Reservoir will be located about 14 miles east of the city of Independence, Kansas, on Big Hill Creek, a tributary of the Verdigris River, as shown on figure III-1 at the end of this report. The reservoir will be a part of the upper Verdigris water resources development composed of Elk City, Fall River, and Toronto Reservoirs.

Stream Characteristics

The stream rises in southwestern Neosho County and flows to the south some 57 miles to the Verdigris River about 1 mile north of Coffeyville, Kansas. Streamflows are highly variable, which is characteristic of streams in this area. Six-year records at the Cherryvale Damsite 1/ show several periods of zero flow, a maximum flow of 3,530 cubic feet per second (cfs) in May 1961, and an average annual discharge of 24.6 cfs.

Water Quality

The only available water quality information for Big Hill Creek is from a sample taken by the Public Health Service on November 16, 1958. This analysis is shown in table III-1. Although one observation is of limited value, the analysis shows that the quality of water, even at this low discharge, is within the upper limits of the 1962 Public Health Service Drinking Water Standards. 2/

Table III-1

Water Quality Analysis of Big Hill Creek
at Cherryvale, Kansas
(November 16, 1958)

Item	Measurement
Discharge	0.5 cfs
Dissolved Solids	386 mg/1
Chlorides	58.9 mg/1
Sulfates	17.0 mg/1
Fluorides	0.06 mg/1
pH	7.5
Total Hardness	239 mg/1

Five years of water quality records are available on Pumpkin Creek, 3/ a Verdigris River tributary adjacent to Big Hill Creek. These records show this water to be of better quality than samples taken from the Verdigris River at Coffeyville. Assuming that the two tributaries, Big Hill Creek and Pumpkin Creek, have similar chemical characteristics, and considering the single sample given in table III-1, it appears that water in Big Hill Creek is of better quality than the Verdigris River.

Pertinent Data

Big Hill Reservoir will be constructed in two stages. The first stage will have a yield of 4.5 mgd while the second stage, which will be built when the need for additional water develops, will yield 8.5 mgd. Pertinent data are shown in table III-2.

Table III-2

Pertinent Project Data

Item	Initial Stage	Final Stage
Dam Location, River Mile	33.3	33.3
Drainage Area, sq. mi.	36.9	36.9
Elevation, feet, m.s.l.:		
Top of Dam	876.0	884.0
Top of Flood Control Pool	855.0	867.5
Top of Conservation Pool	842.0	858.0
Top of Inactive Pool	825.8	825.8
Area, acres:		
Top of Flood Control Pool	1,160	1,500
Top of Conservation Pool	800	1,200
Storage, acre-feet: (1)		
Flood Control	12,600	12,600
Conservation	9,500	25,900
Inactive	2,200	2,200
TOTAL	24,300	40,700
Water Supply Yield, mgd	4.5	8.5

(1) Initial condition. 100-year sediment will be distributed in flood control, conservation, and inactive pools.

IV. PROJECT AREA DESCRIPTION

Location

The project area lies within Neosho, Labette, and Montgomery Counties. As pointed out in the Public Health Service report of 1960, 4/ principal municipalities in the project area which may reasonably be expected to obtain water from the proposed project are Cherryvale, Independence, and Coffeyville located in Montgomery County, and Mound Valley and Parsons in Labette County.

Geography and Topography

Big Hill Creek lies in the extreme southeastern corner of Kansas. The watershed is about 25 miles long and has a maximum width of 5 miles, containing 110 square miles of wooded, hilly, and rolling terrain. The streambed slope varies from about 5.5 feet per mile in the upper three-quarters of the basin to 1.5 feet per mile in the remainder of the basin.

Climate

Weather Bureau records at Independence, Kansas indicate that the average annual rainfall in the area is about 39 inches, varying from 54.6 inches in 1915 to 21 inches in 1952. Temperatures vary from an average low of near 25 degrees to an average high of about 78 degrees.

Principal Communities and Industries

Principal communities of study are Coffeyville, Parsons, and Independence with 1960 populations of 17,382, 13,929, and 11,222, respectively. The basic industry of the area is agriculture with concomitant processing plants. Some mining and petroleum production is carried on.

V. WATER RESOURCES OF THE PROJECT AREA

Quantity of Water Available

Surface Water

The proposed project will serve as part of the water resources development of the Verdigris River basin. Other reservoirs in the system are Elk City, Fall River, and Toronto. Information pertinent to these reservoirs is shown in table V-1.

Table V-1

Reservoir Characteristics
of the Verdigris River Basin

Reservoir	Storage (1000 ac-ft)		Yield (mgd)	
	Flood	Conservation	Municipal and Industrial	Low Flow Augmentation
Elk City	230.7	60.3	10.0	7.4
Fall River	236.0	27.0	0	5.8
Toronto	172.0	23.3	0	7.2

Principal communities in the project area depend on natural flows of the Verdigris River and its tributaries for their water supply, with the exception of Parsons which obtains its water from a reservoir on a tributary of the Neosho River.

Ground Water

Ground water in the area is not adequate to meet the demand of large water users. 5/ Although some small communities and rural households take their supplies from wells, the vast majority of the water users depend entirely on surface water.

Quality of Water Available

To the extent that water quality is represented by the analytical results shown in table III-1, water to be impounded in the proposed project will, with proper treatment, be suitable for municipal and industrial purposes.

VI. ECONOMICS AND POPULATION

Economic and demographic projections presented in the 1960 Public Health Service report 4/ were reviewed, and it was found that no significant developments have occurred which would alter their magnitude.

Industrial expansion, urbanization, and the assurance of adequate water supply are expected to reverse the population trend. Population projections presented in the 1960 Public Health Service report 4/ were extended to 2070 and are shown in table VI-1.

Table VI-1

Present and Projected Urban Populations
Big Hill Reservoir Study Area

Municipality	1960	2020	2070
Coffeyville	17,382	30,000	48,000
Parsons	13,929	25,500	44,500
Independence	11,222	19,500	32,500
Cherryvale	2,783	4,800	8,000
Mound Valley	481	800	1,300
Total	45,797	80,600	134,300

VII. WATER REQUIREMENTS--MUNICIPAL AND INDUSTRIAL

Past and Present Water Use

General

All of the municipalities considered in this study take their water supplies from surface sources, either from channel impoundments or locally owned reservoirs. Water demands for these municipalities are shown in table VII-1.

Table VII-1

Municipal Water Demands of the Area

	1958			1963		
Municipality	Population Served	Demand (mgd)	Unit Demand (gal/day)	Population Served	Demand (mgd)	Unit Demand (gal/day)
Coffeyville	20,000	3.0	150	19,350	2.0	103
Parsons	15,000	2.0	133	14,750	2.0	136
Cherryvale	3,000	0.25	83	3,000	0.28	93
Mound Valley	600	0.02	33	550	0.04	73
Independence	13,000	1.5	115	13,000	1.5	115

Coffeyville

Coffeyville's present source of supply is two channel dams on the Verdigris River. The storage capacity of these dams is believed to be quite small, which means the city must virtually rely on natural streamflow. It is anticipated that Coffeyville will make maximum use of Big Hill Reservoir for a water supply because of better quality and greater dependability.

At the present time, the Cooperative Refinery Company at Coffeyville is taking the majority of its water supply (2.2 mgd in 1959) directly from the Verdigris River. In the future, the Cooperative Refinery is expected to obtain water from the city of Coffeyville.

Parsons

Prior to 1959, the city of Parsons obtained all its water from the Neosho River. Following the drought of the 1950's, when there were long periods of zero flow, it was seen that an additional water supply source must be secured. In August 1959, a new reservoir on Labette Creek was completed with a dependable yield of 7 mgd. This supply, along with the 3 mgd water rights on the Neosho River,

should be sufficient to supply the water needs of Parsons through the year 2020. After this time, they will most likely seek an additional source of supply within their own river basin (Neosho).

Cherryvale

Cherryvale, at the present time, is withdrawing water from the Verdigris River at the approximate rate of 0.3 mgd. However, they feel that they should go to a more dependable source and have indicated an interest in obtaining a water supply from Big Hill Reservoir.

Mound Valley

Mound Valley secures its water from two dams on Pumpkin Creek, with their average daily withdrawal amounting to 40,000 gallons per day. Although the supply seems adequate for the present, they have expressed an interest in obtaining future water supplies from Big Hill Reservoir.

Independence

The city of Independence presently obtains its water from channel dams on the Verdigris River and Elk River, and must rely almost entirely on natural streamflow because of limited storage. Provision was made in planning for the Elk City Reservoir for storage to supply Independence. It is anticipated that definite arrangements will be made to secure water from that source in the near future.

The Future

Based on the population projections in Chapter VI and unit water requirements in the 1960 Public Health Service report, 4/ water demands for the year 2020 and a proposed water supply plan were developed and are shown in table VII-2. It can be seen that the municipal and industrial water demands will amount to 13.5 mgd in 2020 and 22.0 mgd in 2070.

The existing or proposed water resource developments in the area include Toronto, Fall River, and Elk City Reservoirs. Elk City Reservoir has a municipal and industrial water supply yield of 10.0 mgd. This combined with Big Hill Reservoir will give a water availability of 18.5 mgd which will be a deficit of 3.5 mgd in the year 2070.

There will be an immediate need for water in the first stage of the Big Hill project to make more dependable water supply for municipalities in the project area. The second stage of the project will be needed in the year 2020.

Table VII-2

Water Supply Plan - Big Hill Study Area

Municipality	Population	Total Demand (mgd)	Source of Supply (mgd) Big Hill Reservoir*	Other
Year - 2020				
Coffeyville	30,000	7.5	2.5	5.0
Cherryvale	4,800	0.9	0.9	0
Mound Valley	800	0.2	0.2	0
Independence	19,500	4.9	0	4.9
Total	55,100	13.5	3.6	9.9
Year - 2070				
Coffeyville	48,000	12.0	6.6	5.4
Cherryvale	8,000	1.6	1.6	0
Mound Valley	1,300	0.3	0.3	0
Independence	32,500	8.1	0	8.1
Total	89,800	22.0	8.5	13.5**

*Big Hill Reservoir is proposed in two stages. The first stage will yield 4.5 mgd while the completed project will have a yield of 8.5 mgd.

**Other reservoirs in the area have a present conservation yield of 10.0 mgd available for municipal and industrial water supply needs. The area will thus fail to satisfy its water supply demand by 3.5 mgd in 2070 unless a new source of water is developed by that time.

VIII. WATER QUALITY REQUIREMENTS

A minimum streamflow must be maintained in a river receiving treated municipal and industrial wastes to the extent that natural aerobic processes of stream self-purification can occur. The quality of a stream must be maintained in order that maximum utilization for recreational purposes and the support of wildlife can be attained. Of even more importance is the potential reuse of the stream by downstream communities for municipal water supplies.

There is at present no pollution of any significance on Big Hill Creek which would require storage for water quality control. Storage in Big Hill Reservoir to control the water quality in the Verdigris River was evaluated and is presented below.

Minimum flows required to maintain water quality on the Verdigris River below Coffeyville, Kansas, are shown in table VIII-1. The water quality objective is a dissolved oxygen concentration of 4.0 mg/l.

Table VIII-1

Minimum Flows Required Below Coffeyville, Kansas, to Maintain Water Quality

Month	Minimum Flow (cfs)	
	2020	2070
January	13.7	22.4
February	14.5	23.7
March	15.6	25.5
April	18.1	29.7
May	20.5	33.8
June	23.6	39.0
July	26.3	43.4
August	26.3	43.4
September	23.6	39.0
October	18.1	29.7
November	15.6	25.5
December	13.7	22.4

The flow of the Verdigris River at Independence and Coffeyville and the Elk River at Independence will be regulated by releases from Toronto, Fall River, and Elk City Reservoirs. Storage in these reservoirs has been established for the purpose of water quality control with dependable yield for this purpose being shown in table V-1.

In a letter dated October 9, 1964, the U.S. Army Engineer District, Tulsa, Oklahoma, presented flows at Coffeyville, Kansas, resulting from upstream quality control releases and uncontrolled runoff below the reservoirs.

Based on this information, it was determined that a quality objective of 4.0 mg/l dissolved oxygen would be maintained with an exceedence frequency of at least 98 percent and there will be no foreseeable need for additional storage in Big Hill Reservoir for water quality control.

IX. BENEFITS

Water Supply

The benefits of developing Big Hill Reservoir result from the provision of an adequate, convenient, and dependable source of water supply of desirable quality. The value of those benefits is equivalent to the cost of providing the supply from another source.

In practice, a measure of the benefits can be approximated as the cost of achieving the same results by the most likely alternative means that would be utilized in the absence of the project.

In the event that the first stage of the Big Hill Reservoir would not be Federally constructed, municipalities envolved in the water supply plan would necessarily develop an alternate source of supply. It has been determined that the most feasible alternate to the Big Hill multiple-purpose project would be the construction of two single-purpose reservoirs.

One reservoir, located on a tributary of Big Hill Creek, would have a cost of $1,383,000 and an annual operation, maintenance, and replacement cost of $10,900. It would have a yield of 1.5 mgd.

The second single-purpose reservoir, on Big Hill Creek, would have a $2,876,000 cost with annual charges amounting to $24,400 and a yield of 3.0 mgd. This reservoir would not be needed until the year 2020, therefore it will be necessary to allow for a 10-year planning and construction period and discount the total annual costs from the year 2010 to the base year 1970.

Benefits attributable to the first stage development of Big Hill Reservoir are equated to this alternate plan and are calculated in table IX-1.

Table IX-1

Water Supply Benefits for
First Stage Big Hill Reservoir

Item	1.5 mgd Reservoir	3.0 mgd Reservoir
First Cost (Including interest during construction @ 4%)	$1,383,000	$2,876,000
Annual Operation, Maintenance and Replacement	10,900	24,400
Annual Payment of Municipal Bonds with Payment Period of 25 Years at 4% Interest (0.06401)	88,526	184,093
Required Federal Investment to Provide Annual Payment at 3 1/8% Interest (17.17308)	1,520,264	3,161,444
Amortized Federal Investment Over Project Life, 100 Years, 3 1/8% Interest (0.03276)	49,800	103,600
Total Annual Benefit	60,700	128,000
Discounted Annual Cost of 3 mgd Reservoir from 2010 to 1970, 3 1/8%, 40 Years (0.29204)	-	37,400

The combined minimum value of benefits for developing this source of water will be $98,100 annually.

Water Quality Control

Since no need for storage to control water quality is anticipated at this time, as discussed in Chapter VIII, there will be no benefits attributable to this purpose.

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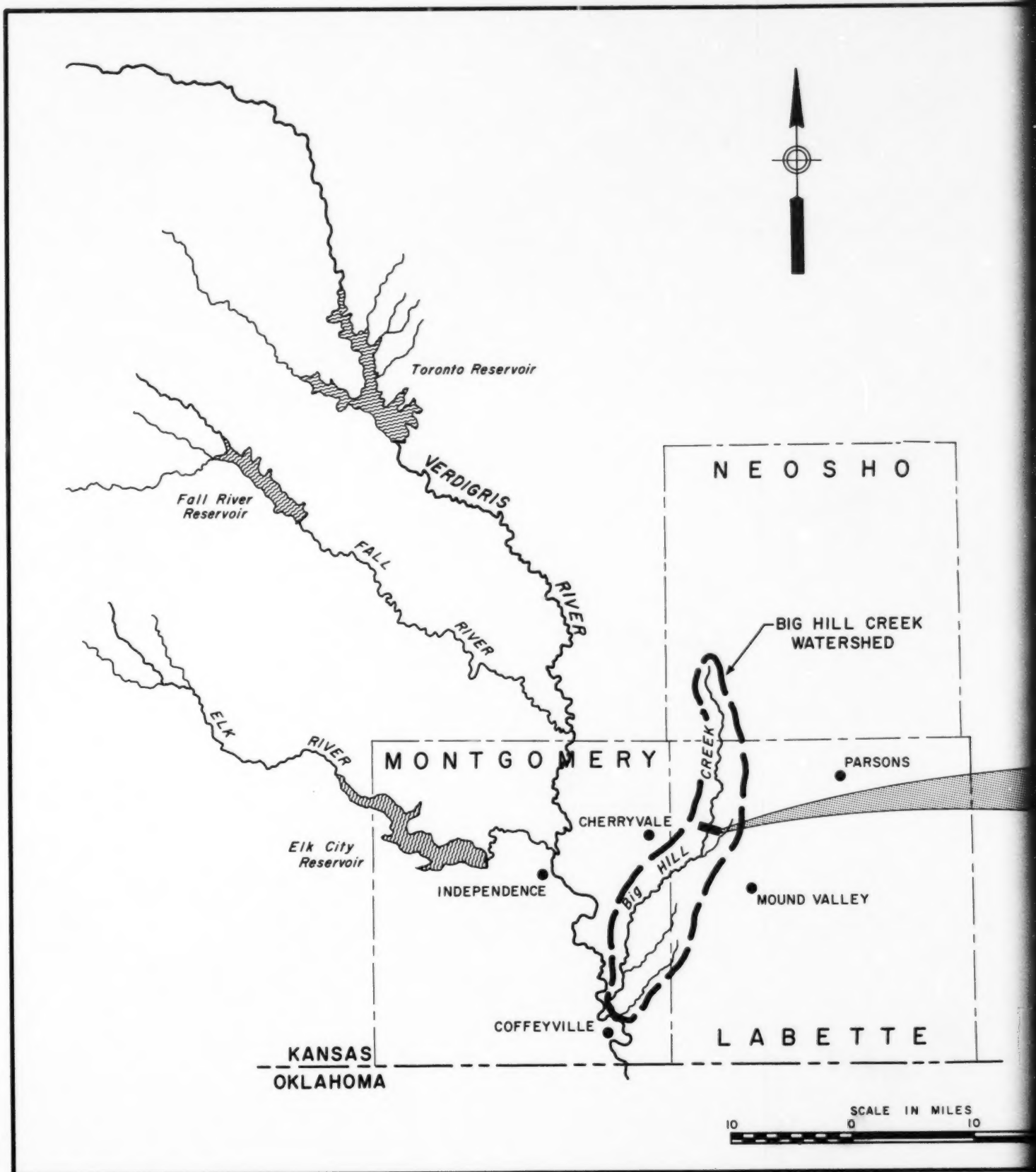
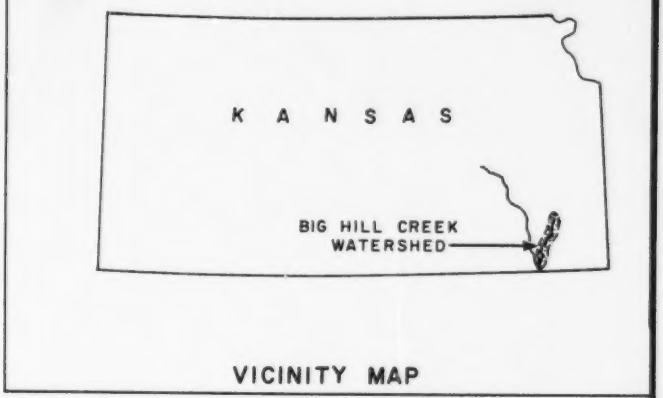
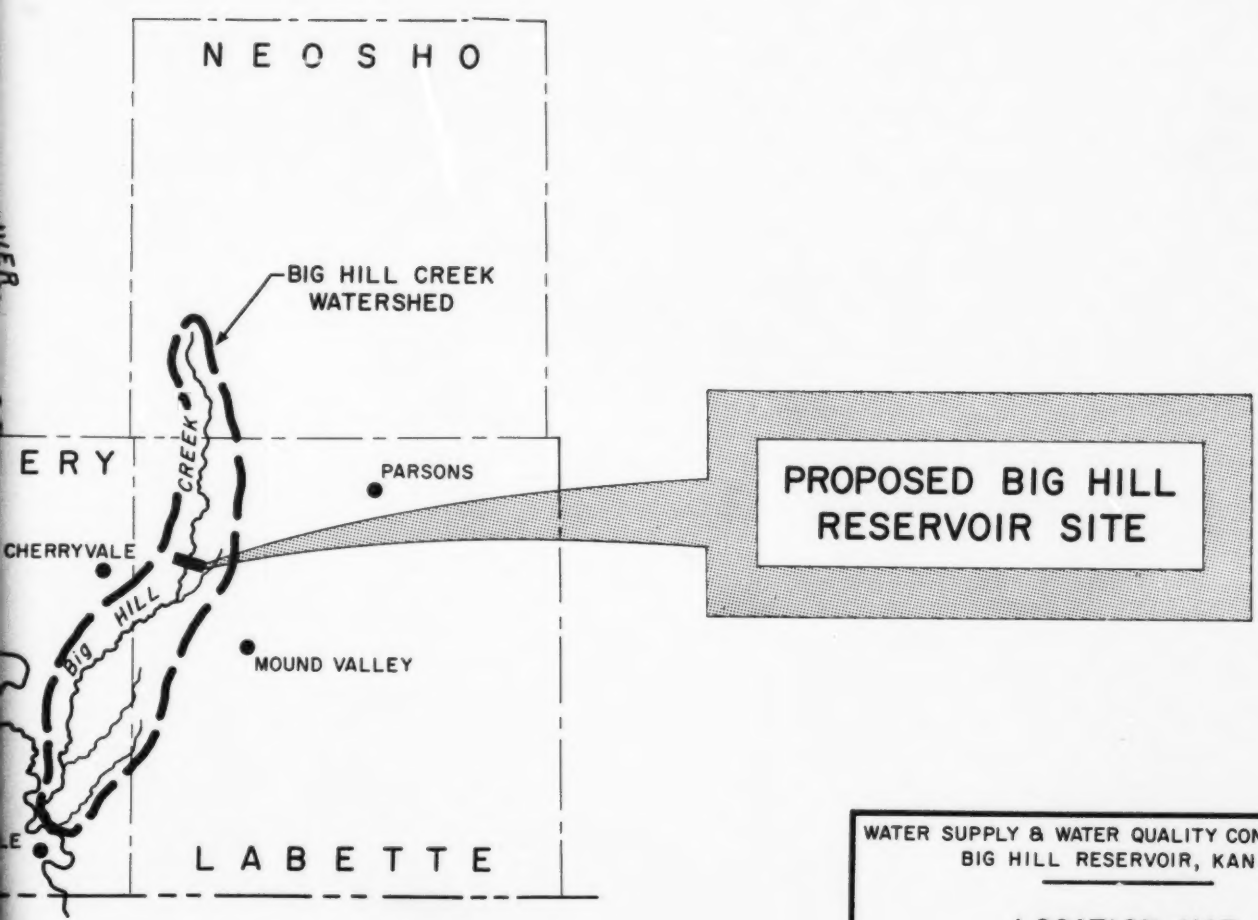

Toronto Reservoir
VERDIGRIS RIVER
Fall River Reservoir
FALL RIVER
ELK RIVER
Elk City Reservoir
NEOSHO
BIG HILL CREEK WATERSHED
MONTGOMERY
PARSONS
CHERRYVALE
BIG HILL CREEK
INDEPENDENCE
MOUND VALLEY
COFFEYVILLE
LABETTE
KANSAS
OKLAHOMA
SCALE IN MILES
10 0 10

X-2



VICINITY MAP



SCALE IN MILES
10 0 10 20

WATER SUPPLY & WATER QUALITY CONTROL STUDY
BIG HILL RESERVOIR, KANSAS

LOCATION MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service
REGION VII DALLAS, TEXAS

FIGURE III-1